cate therefore something as to the age of this latest and perhaps shortest stage of Lahontan history, but they can hardly represent anything more. Tufa deposits above the Pyramid outlet level have no simple relation to the quantity of salines now retained in Pyramid waters, nor can any simple deduction be reasoned therefrom. If Pyramid Lake waters are comparatively fresh, that is more likely to be the result of freshening by overflow than of freshening by desiccation. However, desiccation of Lahontan waters and perhaps of concentrated saline solutions may have taken place in the dry basins to the north. Large quantities of salines were accumulated in an analogous system below the Owens River, and, owing to natural relations there, they have not since been covered up. There is a good chance that similar deposits may have been formed in some concentration sink of the Lahontan Basin, which have since been buried in playa muds.

HOYT S. GALE

WASHINGTON, D. C.

BOTANY IN THE AGRICULTURAL COLLEGES

DR. E. B. COPELAND'S article in SCIENCE for September 18, 1914, entitled "Botany in the Agricultural College," opens up for discussion a many-sided problem of high pedagogical importance to agriculture. While we may agree to the definition "that the raising of crops is essentially nothing more or less than applied botany," it is a pitiful commentary that what we know of the raising of crops has in the main been gained without the help of the botanist. Indeed, one of our best-known American botanists contends that problems of crop production may safely be left wholly to the argonomist and horticulturist.

The chemist infinitely more than the botanist has interested himself in the great problem of securing a larger crop return from the soil. Indeed one must give high credit to the chemists for the insistent efforts they have made to bring their science into affiliation with all other sciences and with practical industries. We have to-day almost endless subdivisions of chemistry, such as biological chemistry, agricultural chemistry, engineering chemistry, physiological chemistry, bacteriological chemistry, etc. There is hardly a line of human endeavor to which the chemist has not striven to apply his knowledge in a practical way. Much of the so-called agricultural chemistry is more properly plant physiology, but chemists have occupied the field with scarcely a protest from botanists. In striking contrast to the chemist, botanists have shrunk from what should be the major application of their science; namely, that of crop production. A marked exception is plant pathology along which line the best contributions of botanists to agriculture have been made. In very recent years the study of genetics as applied to agricultural crops also promises to produce much of high economic value. It is true that there are numerous texts purporting to treat of agricultural botany, but they are mostly of a character creditable to neither agriculture nor botany. The best texts that relate to agricultural botany or at least to crop production have been written not by botanists but by chemists.

Perhaps no one really questions that the study of the factors that go to make crop production is the province of plant ecology and of plant physiology, including genetics, but one may search the whole literature of these subjects without finding a single paper devoted to the relation of any one environmental factor to quantity and quality of yield, the very thing with which crop production is concerned. Botanists seem scarcely to have realized that yield is a measurable result of the same sort as the rate of growth, or the amount of water transpired, or of carbon assimilated.

Our actual knowledge of the relation of factors both external and internal to yield is very largely the work of non-botanists. Indeed, excepting for the work of chemists it is still largely confined to the facts gathered by actual experience in the growing of crops, most of it antedating the development of modern science.

Since the advent of modern science six great discoveries or lines of advance have contributed to greater crop production or at least to a

clearer understanding of the factors involved. These are as follows:

The Gaseous Food of Plants.—Knowledge of these centers about the discovery of carbon dioxide assimilation (photosynthesis) and oxygen respiration, the main points of which were cleared up by Ingen-House (1779–1796) and Senebier (1782–1800). Saussure (1804) first proved that plants combine water with carbon dioxide in carbon assimilation.

The Mineral Food of Plants.—Saussure (1804) recognized clearly the necessity of the ash constituents of plants and that these were derived from the soil. The conception, however, was much older, dating back at least to Palissy in 1563. These ideas, however, met with little acceptance until after 1840, when the writings of Liebig and the experiments of Boussingault, Salm-Harstmar and others cleared up all the important points before 1860. Liebig must be considered as the great dynamic force that impressed the importance of this knowledge on agriculture. While some of Liebig's ideas were erroneous, his writings profoundly affected agriculture and his general ideas of the importance of mineral fertilizers dominated scientific agriculture until the beginning of the present century and still exercise a potent influence. The fertilizer experiments conducted by Lawes and Gilbert at Rothamsted still remain the most extensive of their kind, and their results have contributed much to support Liebig's theory.

The Organic Food of Plants (Nitrogen).—Liebig believed that all ordinary plants obtained their nitrogen directly from the ammonia in the air, but Boussingault (1851–5) proved that various plants would not thrive in a soil containing all essential elements but nitrogen, but grew normally if nitrates were added.

While the fact had been known long previously that ammonia became changed into nitrates in soil, Schlosing and Muntz (1877) first proved that it was due to microorganisms, which were finally isolated by Winogradsky in 1890.

Hellriegel (1888) demonstrated that legumes are able to utilize atmospheric nitrogen through the agency of bacteria in the root nodules. It was previously known that these plants could obtain more nitrogen than was present in the soil.

Plant Breeding.—Three other discoveries have led to great improvement in our crop plants themselves. These are: (1) The proof of the sexuality of plants by Camerarius 1691–4; (2) the hybridization of plants by Kolreuter, 1760–1770; (3) the discovery of the laws of hybridization, Mendel, 1865.

Improvement in Mechanical Appliances.—The development of improved machinery for the tillage of the soil, the sowing of the seed, and the harvesting of the crop has had a profound influence both in increasing the amount and decreasing the cost of production. The invention and improvement of agricultural machinery has been the work of a long list of inventors.

Control of Insects and Diseases.—The important methods for the direct control of insects and plant diseases center about the discovery of Bordeaux mixture by Millardet in 1885; of the use of Paris green for biting insects beginning about 1868; the value of kerosene emulsion for sucking insects about 1877; and the development of fumigation with hydrocyanic-acid gas, 1886–1888.

Indirect methods of control have been greatly advanced by the investigations of both entomologists and plant pathologists.

Of these six lines of advance three are due almost wholly to chemists, one to mechanics, one wholly to botanists, and one partly to botanists and partly to entomologists. It may be argued that the chemists' contributions are really plant physiology, but this does not alter the fact that the work was done by chemists and that further research into the food of plants, at least of crop plants, is still largely directed by chemists and not by plant physiologists.

At the 1914 session of the Graduate School of Agriculture held at the University of Missouri an incidental discussion led to a general expression of opinion regarding the training of American agronomists. There was complete agreement that the botanical side of their training is wholly inadequate. Indeed with

the exception of plant pathology it is exceedingly difficult to find graduates in botany whose training has given them either a taste or a qualification for the innumerable problems surrounding crop production. Almost none take the U. S. Civil Service examinations, the result being that the positions are mostly filled by graduates in agronomy with but meager botanical training.

The result of this condition of affairs is detrimental to the advance both of botany and of agronomy. The young botanist is neither trained nor encouraged to look upon the problems of crop production as the legitimate and greatest field for his future activities. Conversely, agronomy suffers because far too few botanists lend their aid to the study of plants under cultivation.

The charge has sometimes been made that botanists purposely avoid grappling with the enormously difficult physiological and ecological problems that every agronomist and horticulturist encounters. I do not believe that American botanists have ever consciously taken this attitude, but they have been willing to leave the work largely to chemists and others of very limited botanical training. In short, they have not asserted their rights to this field of plant phenomena nor proven them by actual accomplishment.

Botany has progressed greatly in America in the past twenty years, in spite of the fact that it has woefully neglected its greatest application; namely, crop production.

It is difficult to disagree with Dr. Copeland's proposition "that the best scientific foundation for plant industry is a knowledge of plant physiology," except to add that equally necessary is a knowledge of the adaptations of each plant, which is ecology. The fact remains, however, that plant industry or crop production far antedates botanical science, and most of its progress has been purely empirical; that even yet our knowledge of the physiology and ecology of any one crop plant is woefully incomplete.

I would go still further than Dr. Copeland, however, and assert that the whole field of plant culture or crop production is one of plant ecology and plant physiology. Until this is recognized by botanists progress in crop production will continue to be largely the work of non-botanists.

C. V. PIPER
U. S. DEPARTMENT OF AGRICULTURE

IN REGARD TO THE POISONING OF TREES BY POTASSIC CYANIDE

IN SCIENCE of October 9, 1914, was published a short letter telling of a successful attempt at poisoning the cottony cushion scale by inserting cyanide of potassium in a hole bored in the trunk of the tree. I have since received a number of letters asking for further information regarding my "process," and telling me of numerous cases where trees have been killed by poisoning the sap with something beside potassic cyanide. I would accordingly like to take this opportunity of stating that I am not experimenting in either entomology or horticulture; that I have no process, and that I gave in my letter to SCIENCE a plain statement of the method and results of my experiment. I did this in the hope that it might serve as a suggestion to others who are working in the same field.

I was told by several of my colleagues who are working in biological subjects that any poison fatal to insects would kill a tree before I put the cyanide in the trees, and I have read in a recent number of SCIENCE of the destructive effects of putting potassic cyanide and something else under the bark of fruit trees. I have accordingly chopped down the peach tree referred to in my former letter and have examined both the wood and the bark around the hole in which the cyanide was inserted. In both the wood and the bark there was a discoloration around the hole extending less than one eighth of an inch. Outside of this ring I could notice no change in either. I am not positive that as great an effect would not have been produced if the hole had been left empty. One proof that the bark was not seriously poisoned about the hole was seen in the fact that it had begun to grow over the opening. This is also true in the case of the broom and the orange tree referred to in the previous letter. The peach tree was cut down